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ABSTRACT

Characteristics expected of designs and plans for plumbing, mechanical, and electrical systems in the educational facilities of North Carolina are itemized. Each recommendation is identified as legally mandatory, advisable with exceptions, or merely accepted practice. (PGD)

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SCHOOL PLANNING GUIDE SERIES - 4

NORTH CAROLINA DEPARTMENT OF PUBLIC INSTRUCTION
DIVISION OF SCHOOL PLANNING, RALEIGH OCTOBER 1975

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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MINIMUM CHECK LIST

FOR MECHANICAL AND ELECTRICAL PLANS AND SPECIFICATIONS

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MINIMUM CHECK LIST

FOR MECHANICAL AND ELECTRICAL PLANS AND SPECIFICATIONS

DIVISION OF SCHOOL PLANNING • N. C. DEPT OF PUBLIC INSTRUCTION • 1976

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ABBREVIATIONS

AGA	AMERICAN GAS ASSOCIATION	NFC	NATIONAL FIRE CODES
DEM	DIVISION OF ENVIRONMENTAL MANAGEMENT	NSF	NATIONAL SANITATION FOUNDATION
DNER	N. C. DEPT. OF NATURAL AND ECONOMIC RESOURCES	NCBRR	N. C. BOILER RULES AND REGULATIONS — 1974
IBR	INSTITUTE OF BOILER AND RADIATOR MANUFACTURERS	NCGS	N. C. GENERAL STATUTES (AMENDED TO 1975)
IES	ILLUMINATING ENGINEERING SOCIETY	NCSBC	N. C. STATE BUILDING CODE — 1967
NFPA	NATIONAL FIRE PROTECTION ASSOCIATION	SBI	STEEL BOILER INSTITUTE
NEC	NATIONAL ELECTRICAL CODE — 1975	UL	UNDERWRITERS LABORATORIES, INC.

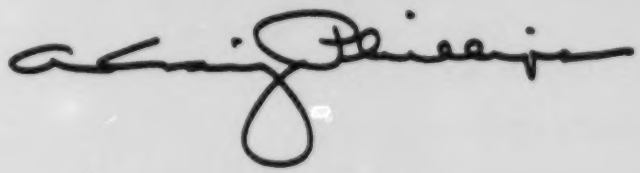
FOREWORD

Students, teachers, parents, administrators, architects and engineers are very much aware of the importance of the physical environment to the educational process. Much progress has been made toward improving the environment, primarily the result of considerable effort on the part of educators and those engineers and architects involved in the design of public school facilities. At the same time, a concerted effort has been made to improve the design and installation of the total mechanical and electrical systems, all to the best interests of the students and the school systems. This, too, has been a joint effort on the part of educators, engineers and architects. For the most part, the results have been very gratifying.

This *Minimum Check List*, or "red book", was developed about fifteen years ago by the Division of School Planning to serve as a means of communication between school agencies and the design professions. It is and should remain a "minimum" check list that includes concise, pertinent, and well-chosen comments without being voluminous. Such is the intention of this fourth revision. It should be noted that the *Minimum Check List* represents the thinking of a representative cross section of the design professions.

This publication is one of many that have been prepared and distributed by the Department of Public Instruction as an aid to the ever changing process of planning and developing public education facilities.

October, 1975



A. Craig Phillips
State Superintendent of Public Instruction

PREFACE

This is the fourth revision of the *Minimum Check List* since its origin in 1960 by the Division of School Planning. It has been widely used in the development and review of mechanical and electrical plans and specifications by engineers, architects and superintendents in planning public school facilities. Apparently the *Minimum Check List* has been well received as a planning tool for these fifteen years. The Division of School Planning is pleased to make available this fourth revision in the hope that it will continue to be a useful publication.

Appreciation is expressed to the following individuals for their assistance in preparing this revision:

Private Practicing Engineers:

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W. H. Price, Division of School Planning

In using this check list, the following interpretations should be kept in mind:

- Items using the term "shall" are mandatory because of law, code or regulation.
- Items using the term "should" are those which experience has taught are most practical and desirable. Any deviation should be supported by adequate information and reasoning and should be cleared with the Division of School Planning in the early stages of the design process.
- Other items are included as good practices about which professional people may not entirely agree.

October, 1975

J. L. Pierce, Director
Division of School Planning
Department of Public Instruction

P-100.00 Drainage, Wastes and Vents

101.00 Floor drains are needed in all toilet rooms containing more than one water closet, and at all points where water heaters are located.

.01 Infrequently used floor drains should have traps resealed by waste from clear water fixtures.

.02 Provisions should be made for resealing traps of floor drains located in rooms being used as return air plenums. It is recommended that these drains be 4" minimum size, and that sediment strainers be used.

.03 Drains in all areas should be not less than 3" size (NCSBC, Plumbing, Section 915.3).

102.00 Floor drains shall not be installed in food storage areas.

103.00 Floor drains shall be provided for boiler rooms, and for mechanical equipment rooms containing any equipment using steam or water, or incorporating cooling coils.

104.00 The plumbing plans must bear the seal of the engineer who is responsible for their design, and is by law obligated to inspect and issue a "Certificate of Compliance" upon completion of the project (NCGS 133-1.1).

105.00 Acid-resisting waste lines should be considered for chemistry laboratories in senior high schools, and perhaps some other special uses such as the chemistry instructor's table in a junior high school. They are not considered necessary for any other normal laboratory areas.

.01 Corrosion-resistant traps are required on all fixtures in chemistry classrooms, and may be used if desired in other laboratories such as physics and biology.

.011 P-traps to the wall, or located below floor, are preferred to S-traps to floor.

.02 Plaster and/or interceptor traps are usually needed for work sinks in areas such as art classrooms.

• 106.00 Vent pipe flashings, at the roof, should be made in two pieces. One of these should be a cap which slides down over top of the pipe, and sufficiently overlaps the base flashing. Copper or lead is preferred.

.01 Screens, to protect against gravel, rocks and etc., are recommended for installation on these flashings.

• *.02* Reference is made to the sizes of vent piping at the point where it passes through the roof. It is recommended that 3" be a minimum size.

107.00 Cleanouts placed in horizontal pipe runs should be fabricated using longsweep one-quarter bends or fittings providing one-eighth turn. Standard one-quarter bends should never be used.

.01 In clay (V.C.) pipe sewer lines, cast iron fittings should be provided at the bases of cleanouts to prevent breaking with end of the sewer rod.

108.00 Roof drainage shall be designed in accordance with requirements of the NCSBC, Plumbing, Chapter XV (as a minimum). Provisions for wind effect should be incorporated in the design, i.e., consider the wind blowing all rain to one side of the roof.

.01 The actual installation of roof drains and flashings, for interior roof drain systems, should be made by the general contractor. Piping for such systems should be by the plumbing contractor.

• 109.00 Reference is made to the NCSBC, Volume 1, Section (11X) entitled "Making Buildings and Facilities Accessible to and Usable by the Physically Handicapped". Appropriate provisions of this section are applicable to plumbing systems in public schools.

• *.01* Water closets, urinals, lavatories and drinking fountains or water coolers must be considered for the handicapped.

P-200.00 Fittings

201.00 All hose bibbs should have minimum 18" clearance underneath.

202.00 A hose bibb with a removable handle or a key operated lock shield should be installed in any toilet room having a floor drain.

203.00 Each fixture should have an individual water supply cutoff valve.

204.00 Flush valves must be equipped with vacuum breakers (NCSBC, Plumbing, Section 1205.1).

205.00 Use freeze-proof hose bibbs where applicable; these should be key operated.

• 206.00 All hose bibbs, including wall hydrants and any outlets with hose threads, must have backflow prevention devices installed (NCSBC, Plumbing, Section 1205.5). For exterior installations, care must be taken to prevent freezing.

P-300.00 Fixtures

• 301.00 Lavatories should be acid-resisting, and have rigid supplies.

• *.01* Strainers, (beehive or grid type are suggested), and not pop-ups or plugs, should be used in lavatory wastes in public toilets and restrooms.

302.00 Elongated bowls and open-front seats for water closets are required by Code (NCSBC, Plumbing, Section 907.1 and 907.6).

• *.01* It is recommended, for male toilets, that water closet seats incorporate the self-raising spring hinge or the self-sustaining friction hinge.

303.00 A lavatory shall be located in the kitchen area for handwashing.

.01 This lavatory shall have a mixing faucet supply fitting.

304.00 A service sink or a receptor should be located within the confines of the kitchen area.

• *.01* Deleted (refer to Item 206.00).

• 305.00 Deleted (refer to Item 206.00).

306.00 Standard, single purpose fixtures should be used where waterworks and plumbing are concerned; i.e., a handwashing lavatory should not be combined with a drinking fountain; a mop sink should not be combined with a handwashing lavatory, nor should one be substituted for the other.

• *307.00* Drinking fountains outside a building shall be frostproof. All wastes from these should be carried to dry wells or storm drains. Dry wells should be located at least 50 feet from water supply wells.

308.00 Counter top sinks should have ledges with holes to receive faucets. Faucets should not be mounted in counter tops.

309.00 Supplies (pipe, valves and fittings) that are concealed, such as for counter top sinks, do not need to be the rigid type, and need not be plated.

310.00 Gymnasium dressing rooms should have drinking fountains. These should not be water coolers.

311.00 Wall-hung type urinals are recommended.

• *312.00* Deleted.

• *313.00* Flow restrictors at shower heads are suggested.

P-400.00 Water Supply (see Sections 7 and 8 of the NCBRR and Chapter XII of the NCSBC, Plumbing)

• 401.00 Wells must be located away from possible sources of contamination, properly protected, and well sites must be approved by a representative of the Division of Health Services, DHR.

• 402.00 At school sites where well water systems are planned, owners, architects and engineers are urged and encouraged to consult the state DNER, Division of Environmental Management for geological information.

403.00 Plans shall show the location of the well, and complete details of the well supply system including well, pump, pump house, piping and storage tank.

• *.01* When an elevated tank is installed, it is strongly recommended that a fire hydrant be properly located on the site, or that a hose connection be provided on the standpipe, or both.

• *.02* When new well supply systems are used provisions for continuous chlorination are strongly recommended.

404.00 When water is obtained from a public system, plans shall show location of the water supply connection, and size of the water meter.

.01 Pressure reducing stations should be utilized where supply pressure exceeds 75 psig.

405.00 Dishwashing and showering are the two factors to consider in sizing water heating equipment. Such equipment must be placed where components can be easily maintained.

.01 180-degree water heaters should carry the NSF label, or equal (NSF Standard No. 5).

.02 Sanitizing hot water from water heater to dishwasher booster heater should be recirculated by pumping in order to maintain maximum temperature at the booster.

406.00 Water heaters and/or storage tanks must have safety valves that are sized and installed in accordance with requirements of the NCBRR.

• *.01* Water heaters incorporating the use of dip tubes must conform to the requirements of the NCBRR, Section 6, Rule 9.

407.00 All hot water storage equipment should have tanks equipped to prevent interior corrosion.

• 408.00 For electric water heaters of all types, the engineer must be careful to comply with (1) all the requirements of Article 422-14 in the NEC; and (2) NCBRR requirements for the UL label. Control voltage should always be volts to ground such as 120-volts or 277-volts.

• *.01* A time clock should be incorporated in the controls for an electric water heater (except for a small one) to provide for on and off periods to assist in minimizing the electrical system demand factor.

• 409.00 State Department of Labor operating certificate shall be mounted under glass and placed near the heater (NCBRR, Section 6, Rule 5).

• 410.00 Circulators for domestic hot water use should be all-bronze construction. Control should be by time clock as well as temperature.

• *.01* All starters for circulators (pumps) using 3-phase current must incorporate overload protection for all three phases (NEC Article 430-37).

• 411.00 All water supply systems should be disinfected before being placed in service. (NCSBC, Plumbing, Section 1209).

• 412.00 It is mandatory that the engineer designate on a plumbing drawing the source of water supply.

• 413.00 Multiple water heater installations (two or more at one location) should incorporate piping arrangement at both inlet and outlet to provide for balanced flow. Also, valves should be provided so that either heater can be isolated separately.

P-500.00 Sewage Disposal Systems

501.00 Locations and principal elevations of connections to public sewer systems shall be shown on plans (NCGS 130-13).

• 502.00 When an on-site sewage disposal system or addition to an existing system, is required and planned, the following considerations are applicable.

• *.01* Application must be made to the DEM, DNER. Contact the regional engineer for the region that includes your area.

• *.02* Both the site (new or existing) and the proposed system (new or existing) must be approved by the DEM.

• *.03* It is of the utmost importance that that agency be consulted prior to procuring a site where on-site sewage disposal is contemplated.

• *.04* Plans and specifications for the proposed sewage plant, or addition to existing, should be prepared in accordance with DEM recommendations, and must be submitted to that agency.

• *.05* DEM approval for the project must be made before the State Superintendent of Public Instruction issues the Certificate of Approval.

503.00 Plans for sewage disposal systems shall include complete details and elevations of all units and appurtenances, including profile from buildings to final point of waste disposition.

504.00 There should be a complete summary of plumbing loads, in fixture units, shown on the plans.

505.00 For aeration type sewage plants (on-site): (1) a suitable fence (which should include barbed wire at the top) is mandatory to exclude children from this dangerous area, and (2) the manufacturer's standard covering for the entire tank is recommended.

• 506.00 All plans, whether for new work or addition to existing, must indicate clearly whether sewage disposal is to a municipal system or to an on-site system.

• 507.00 When sewage disposal will be to a municipal system, check should be made to assure that the system can accept the additional load.

• **P-600.00 Gas Systems**

• 601.00 All gas systems, whether for LP or natural gas, must conform strictly to the requirements of the NFC, Section 54, Volume 2 entitled "Gases". Applicable also is Volume III of the NCSBC.

602.00 In particular, the two areas in Section 54 that are of most concern are (1) the kinds and types of pipes that are acceptable for gas; and (2) the allowable methods for installing pipe with respect to routing, placement, special treatments and valving arrangements.

• 603.00 The Division of School Planning recommends that pipe, and not tubing, always be used for gas systems. Welded joints, for larger sizes, are considered good practice.

604.00 It is recommended and requested that all gas piping be specified to have a 100 psi air test with soap solution applied to all joints.

• 605.00 In all localities where applicable, the engineer should specify that a permit for installation of gas appliances must be obtained, and local inspection of the work must be requested.

• 606.00 In locating gas-fired water heaters, in either new or existing facilities, the engineer must assure that there will be adequate air for combustion and proper ventilation for the space.

P-700.00 Grease Traps

• 701.00 Exterior grease traps should be installed when recommended by the controlling agency. Applicable directions and instructions should be closely followed. A standard size, concrete septic tank is recommended, with capacity to be approximately 500 gallons.

702.00 Interior grease traps are not recommended and should not be used.

CHART—PLUMBING FIXTURE RECOMMENDATIONS

FIXTURE AND APPLICATION	MOUNTING HEIGHTS	FIXTURE-STUDENT RATIOS
WATER CLOSETS		
Grades Kindergarten through Three, Boys	13"	1 to 40
Grades Kindergarten through Three, Girls	13"	1 to 30
Grades Four through Six, Boys	15"	1 to 40
Grades Four through Six, Girls	15"	1 to 30
Junior and Senior High Boys, Seven through Twelve	15"	1 to 50
Junior and Senior High Girls, Seven through Twelve	15"	1 to 40
URINALS		
Grades Kindergarten through Three	18"	1 to 30
Grades Four through Six	20"	1 to 30
Junior High, Seven through Nine	22"	1 to 30
Senior High, Ten through Twelve	24"	1 to 30
LAVATORIES		
Grades Kindergarten and One	24"	1 to 35
Grades Two through Six	27"	1 to 35
Junior and Senior High, Seven through Twelve	31"	1 to 40
DRINKING FOUNTAINS		
Grades Kindergarten through Three	24"	1 to 50
Grades Four through Six	28"	1 to 50
Junior and Senior High, Seven through Twelve	34"	1 to 75
SHOWERS (SEE NOTES BELOW)		
Elementary Boys and Girls	50"-56"	—
Junior High Boys, Seven through Nine	72"	1 to 4
Junior High Girls, Seven through Nine	60"-66"	1 to 4
Senior High Boys, Ten through Twelve	72"	1 to 4
Senior High Girls, Ten through Twelve	66"	1 to 4

Notes: (1) Ratios are for physical education installations, which are more than adequate for athletics. Figure one shower for each four persons in P.E. at time of largest class.

(2) Shower mounting heights should be measured from the finished floor to the center line of the shower head. It is assumed that shower heads will be the fixed type.

M-100.00 General

101.00 The State Department of Labor boiler and tank operating certificate shall be mounted under glass in the boiler room (NCGS 95-65, 95-65.1).

• 102.00 Adequate free combustion and ventilation air shall be provided in the boiler room (NCBRR, Section 9, Rule 17 (b)).

103.00 Motor overload protection must be as specified by the NEC. For three-phase motors, protection is necessary for all three phases (NEC 430-37).

104.00 Gutters are prohibited on range hoods. The range hood should be mounted so that there is a minimum of 6' 6" and a maximum of 7' 0" clearance from the floor, and it should be constructed so that there is at least 12 inches vertical rise on the inside before the hood starts to taper. Range hoods should cover the entire area of the cooking equipment, and surround such area by at least six inches.

• *.01* Capacity of the range hood fan should be approximately 100 cfm per square foot of hood area. A two-speed fan is recommended.

• *.02* It is recommended that ventilation air be discharged straight up all the way; if this is not done, appropriate cleanout doors should be provided.

• *.03* Automatic fire extinguishing equipment must be installed in kitchen range hoods. (NCSBC, Volume III, Section 909).

• 105.00 Adequate quantities of make-up air should be provided for all exhaust fans. Filtering and tempering air should be considered where this is desirable.

• 106.00 Engineers should size all valves on the plans if they are other than full pipe size.

107.00 There should be a complete heating summary shown on the plans, either all or in part as is appropriate for a given school, as follows:

.01 The new load.

.02 The existing load; where this information is not available, the owner should make arrangements to provide it either by the design consultant or some other means.

.03 The capacity provided for known future expansion.

.04 The spare capacity provided if this is different from Item 107.03.

.05 The domestic hot water load where applicable.

• *.06* The net SBI or IBR capacity of the boiler or boilers, where applicable.

• 108.00 Heating and cooling design conditions shall be stated on the plans.

109.00 The mechanical plans must bear the seal of the engineer who is responsible for the design, and is by law required to inspect and issue a Certificate of Compliance upon completion of the project (NCGS 133-1.1).

110.00 Boiler room floors should be at or above grade elevation unless there is some important reason for going below grade.

111.00 The engineer should select all "running" equipment with respect to the noise and vibration factor, especially that which is to be used in or adjacent to occupied spaces.

M-200.00 Stack and Breeching

201.00 Stack

.01 There should be a hinged cleanout door for the chimney.

.02 A flue lining is required (NCSBC, Section 1002). Coordinate with the architect.

.03 A precast flue thimble or fire brick lining is needed where the breeching enters the chimney. Coordinate with the architect.

.04 Connections at the thimble, breeching and chimney must be airtight for efficient operation.

.05 For coal fuel and on new work, the use of induced draft fans is discouraged. In all cases, chimneys should be of sufficient heights to effect proper smoke abatement.

.06 An induced draft fan should be supported independently of the breeching, have an expansion joint between it and the breeching, and should not obstruct normal access to the boiler.

• .07 When metal chimneys are specified, as they might be for oil or gas fired equipment, the provisions of the NFC, Volume 4, NFPA 211 shall apply. The materials used and the establishment of proper clearances are of considerable importance.

202.00 Breeching

• .01 The breeching should be supported independently of the boiler, and should be insulated for oil and coal fired installations.

.02 Enough cleanouts, properly located, should be provided to promote easy, periodic cleaning.

.03 A barometric damper should be used where applicable.

.04 In multiple boiler installations, a locking-type damper should be installed in each separate boiler breeching.

M-300.00 Boilers

• 301.00 There shall be at least three feet clearance on top of low pressure boilers (NCBRR, Section 9, Rule 17 (a)). Three feet clearance is also recommended on the sides as a minimum.

.01 Low pressure boilers with manholes should have at least four feet ceiling clearance.

• .02 The ceiling clearance is five feet for high pressure boilers.

• 302.00 The safety and/or relief valve capacity must be specified (NCBRR, Section 5, Rule 9).

303.00 For tube removal and cleaning, steel boilers shall have minimum clearance of the length of the longest tube, plus 12 inches, at the front.

.01 Cast iron boilers should have sufficient clearance for cleaning and firing. This is normally the length of the boiler plus 12 inches.

• 304.00 When sections are added to a cast iron boiler, the name plate and safety valve must be changed to comply with the new rating (NCBRR, Section 5, Rules 9(g) and 10(c)).

305.00 Boiler ratings

.01 The SBI net rating should be shown for a steel boiler. Boiler selection should be made with respect to load, piping and pickup.

.02 The IBR net rating for a cast iron boiler should be specified.

.03 Where catalogues show only gross boiler ratings, care should be taken to determine the true net ratings, and proper selection should be made with respect to both the direct connected load and necessary pickup and piping losses (as applicable to schools).

• 306.00 Deleted. Note: Stoker references that are deleted will be made available as a supplement to this publication.

• 307.00 Safety valve and relief valve discharges should be installed in accordance with the NCBRR, Section 5, Rule 13.

• 308.00 The discharge line from the safety and/or relief valve shall be supported other than by the valve itself (NCBRR, Section 5, Rule 13).

309.00 Use copper wire to secure the insulation to the boiler unless insulation studs are used.

310.00 Do not cover manholes, rodholes, name plate or ASME stamping on the boiler.

311.00 If the boiler has a hot water heating coil in it, the coil shall be connected in such a manner that the coil cannot be subjected to pressures above those for which it was designed. A pressure relief valve is necessary for this coil.

• 312.00 The boiler bottom blowdown valve or valves, and piping, must be sized and arranged in accordance with requirements of the NCBRR, Section 5, Rule 18.

313.00 The return connection at the rear of the boiler should be connected to either the center tap or to the center of a header connecting the two outside taps in order to provide even return flow into the boiler.

314.00 Boiler piping, as installed, should not restrict the use of the smoke hood cleanout door, manhole openings, and plugged openings.

315.00 A minimum of one brick course or a 3" thick concrete base should be installed under a boiler and its firing device to prevent corrosion.

316.00 Brick and refractory settings for boilers usually should be done by qualified refractory contractors.

317.00 Cross-type fittings should be used on steam boiler piping at water columns, water feeders and LW cutoffs for cleaning purposes.

318.00 When specifying steam boilers, engineers should be very careful to properly evaluate the steam and water capacities (volumes) of the boilers in relation to the system served, and in relation to the kind of firing to be applied (gas, for example). Too little capacity results in some severe problems such as difficulty with holding the water line. The method of feedwater control becomes very important, and this should be properly designed and shown in detail on the plans. Each steam boiler application should be fully engineered to suit the system it will serve.

• **M-400.00 Deleted. Note: Stoker references that are deleted will be made available as a supplement to this publication.**

M-500.00 Oil Burners and Oil Storage Tanks

• *501.00* Light fuel oils, unheated, are recommended rather than heavy oils.

502.00 Oil burner controls.

• *.01* A cadmium cell relay is satisfactory for approximately 3 gph and lower firing rates.

• *.02* An electronic, program type primary control should be used for a firing rate greater than 3 gph. In addition to safety cutout, this would provide prepurge and postpurge of the boiler; purging should definitely be provided.

• 503.00 If the combustion chamber is to be job fabricated, design should be exactly specified and detailed on the drawings. The desired materials should be set forth, and design should be in strict accordance with manufacturer's recommendations.

• 504.00 Oil storage tank capacity should be relative to the size of the heating plant, and to local service and delivery conditions. Normally a 10,000-gallon tank, minimum capacity, is required to obtain lowest fuel oil cost through central purchasing.

505.00 The tank should be thoroughly coated externally with a suitable protective compound, in the field, just prior to installation. A good treatment would be one coat of red lead paint and two coats of black asphalt.

506.00 Tank should be fabricated of heavy gauge metal, and should bear the Underwriters' label.

507.00 Tank shall be installed in strict accordance with all governing fire and building codes.

.01 All tanks should be installed underground.

.02 Fill end of tank should be 4" to 6" low.

508.00 Tank should be adequately anchored.

M-600.00 Steam, Hot Water and Cooling Piping

601.00 Pipe tunnels are recommended, and should be large enough to work in. This recommendation applies to those cases where pipe must be placed below grade or below floor slab. (Please see next item).

• 602.00 Heating or cooling pipe should never be placed underground or below slab on grade unless there is no other choice. Condensate lines, which must necessarily be placed underground at times, should be copper, Type "K", or some other material that is especially corrosion resistant. Fittings for copper pipe should be wrought type, and joints should be made with 95-5 solder or better.

603.00 When it is necessary to install condensate pipe underground (that is, under a slab on grade), the practice of placing the pipe, wherever possible, outside the periphery of the building is highly preferable to placing it under the slab.

• 604.00 Insulation in the boiler room should have a protective jacket applied.

605.00 Pipe anchoring and provisions for expansion (by means of expansion fittings, swing joints or expansion loops) must be provided where necessary.

606.00 Install unions in all pipe lines for the removal of traps, valves, strainers, etc., except when the fitting is the combination union or flange type.

607.00 A piping hook-up detail for each piece of heating and cooling apparatus, including boilers, pumps, hot water generators and tanks, converters, radiation units, forced air heating and cooling units and drip assemblies, and for all points where special piping conditions exist, should be shown on the plans.

608.00 Pitch directions for all heating and cooling (water) lines should be shown on the plans.

609.00 The locations of piping runs (such as above ceilings, exposed at ceilings, etc.) should be indicated by notes on plan drawings.

• 610.00 In a combination hot water-chilled water system incorporating a boiler, piping must be arranged and valved so that chilled water cannot circulate through the boiler (NCBRR, Section 5, Rule 27). Also, hot water must not circulate through the chiller.

M-700.00 Radiation and Unit Heaters

• 701.00 Individual control valves should be sized large enough not to restrict capacities. Two-position valves should be full pipe size.

702.00 Strap-on limit controls, to prevent cold operation, should be installed on all unit heaters and cabinet heaters that are not used also for ventilation or cooling. Unit heaters in shops, for example, that are desired for circulating air separately from heating may include an additional on-off-automatic control to accomplish this.

703.00 Valves, balancing cocks and traps should be accessible (not behind covers without access panels).

704.00 The fronts and ends of radiation covers should have a minimum thickness of 16 gauge.

M-800.00 Controls

801.00 Engineers should specify in detail all controls, and describe sequences of operation.

802.00 All controls, starters, switches, etc., should be permanently labeled after installation.

803.00 Heating control diagrams should appear on the plans.

804.00 Rigid guards, of cast iron or similar construction, are needed to cover thermostats in gymnasiums, dressing rooms, shops, corridors, restrooms and other unsupervised areas.

• *.01* All thermostats should be located on the plans.

• 805.00 Deleted. Please refer to Item 306.00.

806.00 When an induced draft fan is used, a prepurge and low draft switch should be installed. Postpurge should not be used on stoker installations. Manufacturer's recommended pipe size from the breeching to the controller must be followed.

• 807.00 Any control circuit for any kind of space heating device or water heater should be a phase-to-ground circuit. A phase-to-phase circuit should not be used. Voltages recommended are 120-volts, 277-volts and 24-volts.

• 808.00 As an important factor in conserving fuels and energy it is of the utmost importance that (1) clock control and (2) night set-back control be provided for all space heating and cooling equipment. Also, clocks or timing controls are oftentimes applicable to exhaust fans.

• *.01* In most cases, cooling equipment should be turned off altogether during unoccupied periods (nights, weekends and holidays).

• *.02* The control consideration referred to here means turning off all equipment, including pumps, unless some of it is needed to prevent freezing.

• *.03* Boilers should be controlled in such a manner as to use the least possible amount of fuel during off heating periods.

• *.04* Outside air dampers should be kept closed on night setback, and during start-up and warm-up periods.

M-900.00 Hot Water Heating Systems

• 901.00 Feed or make-up water to the boiler should be fed at the return connection to the boiler and shall be piped to comply with NCBRR, Section 5, Rule 22.

902.00 There should be a valved bypass around the pressure regulating valve serving the system.

• 903.00 The low water cutoff should be installed normally in the riser line off the boiler nozzle (NCBRR, Page 72, and the diagram entitled "Hot Water Boilers in Battery" that follows herein).

• 904.00 A balancing line is good practice if more than one compression tank is used.

• 905.00 Air control fittings at boilers and compression tanks are necessary. On large installations the use of separate chamber air elimination devices is recommended; these are pressure vessels and must be so treated.

.01 A shut-off valve should be installed in the pipe line to each expansion tank for servicing.

906.00 Hot water circulating (heating) pumps should have bronze impellers.

• 907.00 Deleted. Please refer to Item 306.00.

908.00 Reverse return design of hot water heating or chilled water system piping is highly desirable, and should be used.

909.00 Automatic valves should be the same size as the pipes except where modulating valves are used.

910.00 In multiple boiler installations, piping arrangement at boilers and pumps should be such that water flow is equally divided through each boiler. With respect to balanced flow and direction of flow, attention is called to the diagram that follows in this section as a recommended arrangement. In general, pumping away from the boiler(s) to the system is by far the most workable method.

• 911.00 All compression tanks should be specified to meet ASME Code construction, and be so stamped. Sight glasses should not be installed on tanks.

912.00 Manual type air vents should always be used instead of the automatic type.

• 913.00 For economical reasons, the installation of standby pumps is not recommended. When warranted, a spare motor could be supplied. There may be times when parallel pumping could be a worthwhile consideration.

914.00 Pumps shall have a cutoff valve on each side for servicing. One valve may be an air-tested balancing cock.

915.00 A simple flow diagram is usually a big help in defining the system.

• 916.00 Boilers must never be piped for reverse flow. Pump away from the boiler in most cases.

• 917.00 When roof top heating equipment is used in conjunction with hot water, it is obviously poor practice to install HW coils in the units themselves because of possible freeze up. Such coils should be located in duct work down inside the building.

M-1000.00 Steam Heating Systems

• 1001.00 The low water cutoff and safety water feeder should be set at a level 2½" below the normal water level of the boiler (NCBRR, Section 5, Rule 20).

1002.00 The condensate pump should be sized for the net capacity of the boiler.

1003.00 The condensate pump should have a cast iron receiver.

.01 Vertical, underground type pumps are preferred over floor-mounted types installed in pits.

M-1100.00 Gas Heating Systems, Gas Burners and Gas-Fired Boilers

1101.00 Gas heating systems, direct-fired, must be installed in accordance with provisions of the NCSBC, Section 2902. Any other type of direct-fired system is not permissible.

1102.00 When a direct-fired, gas system is to be used for a public school building, it is urgently recommended and requested that the designing engineer and architect hold a meeting in the preliminary stages with the Division of School Planning and the Department of Insurance, if necessary, to discuss the matter in detail. This would be highly beneficial to all parties concerned with respect to system and equipment selections, and in avoiding design considerations prohibited by code and/or law.

1103.00 Gas burners, for boiler firing, are recommended to be of the atmospheric (non-pressure) type in the lower range of sizes (up to approxiamtely 2,000,000 btu input). Factory engineered units, incorporating boiler and burner, are preferred over other types.

• 1104.00 Use and proper application of the best grades of gas combustion equipment and safety controls are mandatory. All equipment and controls should be specified to be in strict accordance with manufacturers' recommendations and the best accepted practices, and they must meet requirements of the AGA. The engineer is reminded here that control equipment set forth in printed material by manufacturers, although it is probably adequate from a safety standpoint, is usually minimum. Hence, combustion control components should be carefully engineered to produce the degree of safety and performance needed in public school applications. Attention is called to the requirements of NCBRR, Section 5, Rule 25. Please refer to the diagrams that follow herein.

1105.00 The approved methods of installing gas piping, and the types of pipe and fittings to be used are of considerable importance. Specifications and/or plans should state these items in detail. The requirements of NFPA 54 are mandatory, and hence should be adequately shown and described.

1106.00 Gas piping test should be the same as that referred to in Item P-604.00.

• 1107.00 It may be worthwhile, in gas-fired boiler installations, to consider the installation of combination gas-oil burners to provide dual fuel capability.

1108.00 Pipe lines venting gas from appliances or devices must terminate outside the building.

M-1200.00 Electric Heating Systems

1201.00 Each proposed electric heating application should be evaluated with respect to the energy unit cost (per kw-hour). That is, the engineer should assure that the owner will receive an energy cost rate at or very near the all-electric rates for public schools as set forth by the major power companies. This is a vital factor in determining whether to select an electric heating system.

• 1202.00 All items of electric equipment installed in North Carolina public schools must bear the Underwriters' Laboratory Label as required by NCGS. This is true for any and all electrical equipment installed in any kind of system.

• 1203.00 Safety, and all the requirements of the NEC are mandatory in electric system design. Specifically, attention is directed to the 1975 National Electric Code, Article 424-Fixed Electric Space Heating Equipment.

1204.00 When large electric heating systems are to be used (and assuming that the school will be all-electric), 277/480-volt (265/460-volt) electrical systems will usually be applicable and desirable.

1205.00 The conductor insulation for supply connections and other field wiring for electric heating apparatus should be specified. Insulation with a higher temperature rating than TW is usually required in these instances.

1206.00 In toilet rooms, locker rooms and any other such areas subject to wetting or washing down, electric heating apparatus should not be placed near the floor.

• 1207.00 Deleted.

• 1208.00 When demand metering (for billing purposes) is to be applied by the power company, care should be taken to stagger the starting of loads to minimize the demand factor. See Item E-117.00.

M-1300.00 Ventilating

• 1301.00 The Division of School Planning, recognizing the importance of proper ventilation, recommends that consideration be given to providing mechanical ventilation for all the occupied spaces in a public school building. Minimum quantities of air would then at least meet requirements of the NCSBC.

1302.00 Mechanical ventilation may be provided by means of a separate intake and exhaust system, or by means of integration with the heating-cooling system. The latter method is much preferred.

1303.00 When ventilation air is introduced into a space adequate provision must be made for air relief.

1304.00 Variable volume ventilation systems, whether separate or integrated with heating or cooling equipment, are very useful in the North Carolina climate.

1305.00 Mechanical ventilation is vital to gymnasiums, locker rooms, certain storage rooms, dressing rooms, laundries, toilet rooms and janitor's closets.

.01 It is appropriate to provide for year-round, timed operation of ventilation equipment for areas where uniforms are stored.

.02 Mechanical ventilation (exhaust) is recommended for any toilet room, whether or not a window is provided, that has more than one water closet.

.03 A sound trap should be installed in a duct system serving two or more toilet rooms.

1306.00 Food storage room ventilation: This is necessary, and should be done by means of introducing outside fresh air near the floor and expelling exhaust air through the roof, all by gravity flow.

1307.00 Paint spray rooms demand special treatment with respect to ventilation and safety requirements. Paint spray booths, commerical type, are recommended. If one is not to be used but a paint spray room is desired, the engineer should be careful to investigate this matter thoroughly with respect to regulations and codes.

M-1400.00 Air Conditioning (Cooling)

1401.00 Cooling is recognized as a desirable and useful feature in public schools. It is felt that cooling should be considered for schools or portions of schools that will be used for either full or part-time summer school programs.

.01 Cooling should be provided for all interior classrooms without exception.

• 1402.00 Any of the types of cooling systems that conform to good engineering practices are acceptable. The type of system used, however, should be given careful consideration with respect to each individual case. The economics of both the first cost and the operating and maintenance cost should be analyzed.

1403.00 It is looked upon as good practice to consider provisions for future cooling in any new school that is not to have cooling installed initially. This is to say that system design, related equipment and services could all be considered in the light of adding cooling at a later time.

1404.00 Cooling load summaries should be shown on the plans in the same manner as for heating.

1405.00 Consideration should be given to providing humidification control in air conditioning systems. This is very important when conditioned spaces are carpeted.

1406.00 In central plant A/C systems careful selection of the refrigeration equipment is important. Proper evaluation should be made of capacities, flexibility, space requirements, noise and vibration factors, operating and maintenance costs and etc. Load diversity should be considered where applicable. The type of refrigeration machinery to be used, reciprocating, centrifugal, hermetic or open should be carefully investigated and evaluated.

1407.00 Self-contained, unitary A/C equipment is acceptable where applicable. However, such equipment should be very carefully evaluated with respect to life expectancy, capacity limitations, ventilating capability and noise factors.

1408.00 Window type A/C units are not recommended, and should be used only as a last resort.

• **M-1500.00 Mechanical (HVAC) Systems and Equipment; Fuels**

• 1501.00 Apparently the time is here when it is imperative that owners, the design professions and state and local agencies accurately and properly relate the first cost of a proposed facility to projected energy and/or fuel consumption, and its cost. It may be that the least first cost alone should not determine the kind of mechanical system. Careful analysis and investigation should be made to the end of completely informing the owner. Decisions on the type of mechanical (HVAC) system and the fuel to be used could then be made on the basis of the best information available.

• *.01* The kind of analysis and investigation referred to above would probably dictate the use of a computer. By means of the computer a complete life-cycle cost analysis can be forecast. If properly done, this is the kind of study that could be of real value. Such a study would require the expenditure of additional funds by the owner. But the amount of additional expense in comparison with the potential value would be small. Also, this expenditure should be recouped rapidly in savings in operational costs if the results of the study are properly applied. Industry has computer programs available for the complete evaluation of HVAC economics and life-cycle costs. These programs should be evaluated by the design professionals and purchased on their advice.

• *.02* The 1975 General Assembly of North Carolina enacted legislation to provide for the performance of energy consumption analyses on major construction or renovation of buildings in certain cases. These analyses would require the investigation of total life-cycle costs. Owning agencies and the design professions should procure copies of this legislation and become familiar with it. Title of the legislation is, "An Act to Establish Policy for State Agencies to Perform Energy Consumption Analyses on Major Construction or Renovation of Buildings," and it can be found in Chapter 434 of the 1975 Session Laws.

• *.03* Addendum to Policy IV. F. of "Policies, Rules and Regulations of the State Board of Education Governing the Expenditure of the $300,000,000 'State of North Carolina Public School Facilities Bonds of 1973.' "

The State Board of Education on October 2, 1975 adopted, in accordance with Chapter 434 of the 1975 Session Laws, the following amended addendum to Policy IV. F. which will be effective January 1, 1976:

School building plans for each project submitted for approval to the Division of School Planning shall include an analysis of the total energy necessary to operate the school plant during a normal/or average year. This analysis, to be prepared by the designing architect and engineer, shall include estimated energy necessary to heat, cool, and light the building and to operate the equipment essential to both the building and the program. The total annual energy need shall then be translated into cost by type of energy based on current cost of each type of energy; i.e. electricity, coal, oil, natural gas, LP gas, etc. In submitting this information the local board of education shall certify that it concurs in the analysis and recommendation of the design professionals that the type of energy and the type of system in each case is judged to be the most cost-effective in terms of energy conservation, operational costs, and envirionmental considerations.

Unless judged by the Director of the Division of School Planning to be unnecessary because of scope and proposed use of facility, plans for all projects with 40,000 or more gross square feet of floor space shall include a life-cycle cost analysis of the project.

This life-cycle cost analysis shall include but not be limited to such elements as:

The coordination, orientation and positioning of the facility on its physical site.

Thermal characteristics of materials, and the amount of insulation incorporated into the facility design.

The amount and type of fenestration employed in the facility.

The variable occupancy and operating conditions of the facility, including illumination levels.

Architectural features which affect energy consumption.

An energy consumption analysis of the major facility's heating, ventilating, and air-conditioning system, lighting system, and all other energy-consuming systems. The energy consumption analysis of the operation of energy-consuming systems in the major facility should include but not be limited to:

The comparison of two or more system alternatives.

The simulation or engineering evaluation of each system over the entire range of operation of the major facility for a year's operating period.

The engineering evaluation of the energy consumption of component equipment in each system considering the operation of such components at other than full or rated outputs.

In addition to the above elements the life-cycle cost analysis shall include the following information:

The initial estimated cost of each energy-consuming system being compared and evaluated.

The estimated annual operating cost of all utility requirements.

The estimated annual cost of maintaining each energy-consuming system.

The average estimated replacement cost for each system expressed in annual terms for the economic life of the major facility.

"The life-cycle cost analysis shall be certified by a registered architect or registered professional engineer, or by both architect and engineer, particularly qualified by training and experience for the type of work involved, and in conformance with the provisions of G. S. 133-1.1."

Providing the life-cycle cost analysis is considered to be a service over and above the normal service expected and required under the usual owner/architect agreement.

• 1502.00 Mechanical (HVAC) systems that incorporate air handling equipment are encouraged, and warrant serious consideration (rather than just heating and cooling systems that may or may not have separate ventilation). One primary reason for this is that 100% ventilation capability can be built into these systems, and thereby provide economy for cooling with favorable outside conditions. Also, this ventilation capability could supplant cooling if it became absolutely necessary.

• 1503.00 It is not the intent of this publication to suggest any one kind of fuel as an energy source. The owner, with the assistance of his design professionals, should decide on fuel or fuels. Apparently, cost and availability are the two principal factors to consider.

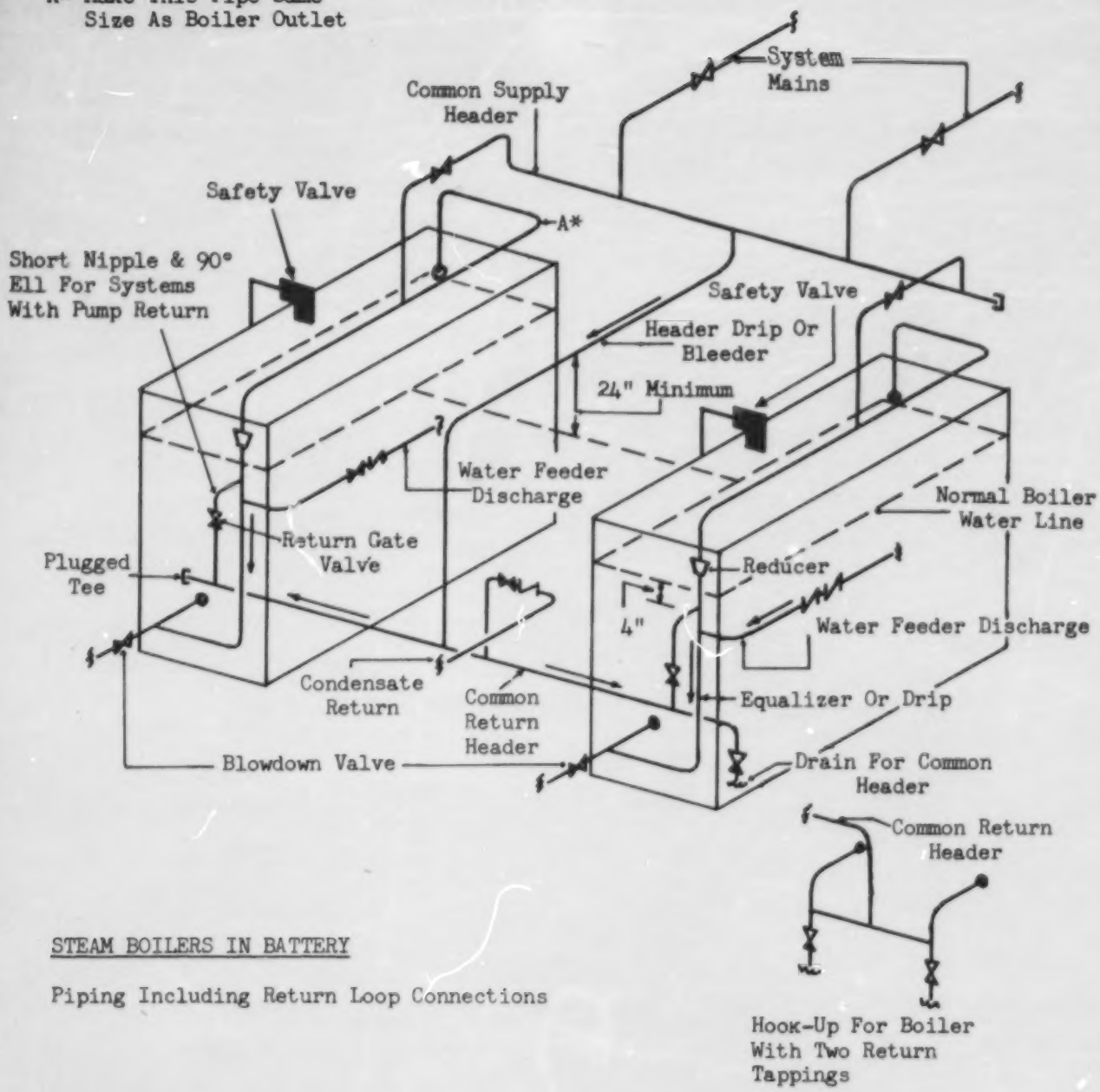
• .01 The use of solar energy for HVAC has become a reality. It is only beginning, but much of the know-how and the hardware are already available. Solar energy is easier to apply for heating than for cooling. Owners and the design professions should investigate the potential of solar energy for any given project, particularly as it might be used for space heating and/or heating domestic hot water.

- 1504.00 If a school is to be all-electric, one consideration in particular could prove to be of great importance in the future. That consideration is whether the HVAC system (particularly heating) should be "wet or dry". Basically, the reference here is to those HVAC systems that incorporate air handling equipment, as terminal units, to heat, cool and distribute air. Historically, most electric heating systems have incorporated straight electric resistance heating elements that heat air directly, and are therefore "dry" systems. Some electric heating systems are designed to use hot water as the heating medium, and this is heated by an electric boiler. Cooling can be and oftentimes is combined with either of these. When hot water is used, for example, a combination of hot water-chilled water can be applied to make up the heating-cooling mediums. Therefore, when electricity is to be used for heating, it could be advantageous somewhere in the future to have a wet system, incorporating a heating boiler, whereby the owner could have the ability to change fuels merely by changing some boiler hardware, or at most by changing the boiler itself. This could prove to cost much less than changing all of the straight electric resistance heating equipment throughout a given system to take advantage of changes in fuels availability or costs. Owning agencies with an interest in such a system should communicate this to the design professions.

- 1505.00 New and modified HVAC equipment and systems are constantly being developed by both the design profession and industry. Heat reclaim, heat recovery or heat transfer systems should be of chief interest among these. Such systems are and will be designed to use the heat input to a building to the fullest extent before it is expelled to the out-of-doors. These systems will claim heat from such sources as lights and bodies and use this as input heat to the heating system. Cooling systems should be designed to take advantage of heat transfer methods and heat rejection methods that will properly assist them in their operation. All of this is an effort to reduce heat (energy) input to a building and thereby conserve fuel and reduce total fuel costs. In the future, where it may be possible to advantageously use such systems and where good engineering practices are indicated, owners and the design professions should investigate their potential.

- 1506.00 Rooftop HVAC equipment has been used extensively in the last few years. Experience with such equipment has emphasized several important considerations. (1) Because of the harsh conditions imposed by operating out-of-doors, only the most durable equipment should be specified. Longevity then becomes a question; equipment with top quality hardware and finishes exposed to the weather is all that should be considered. (2) Frequent maintenance will be a necessity, and high priority should be given to selection and design for ease of maintenance. (3) Roofs are vulnerable; it is recommended in all cases that suitable walkways be provided on roofs for access to and around all rooftop equipment. The Division of School Planning recommended heretofore and still recommends that serious consideration be given to adequately sheltering or fully enclosing rooftop HVAC equipment in all cases.

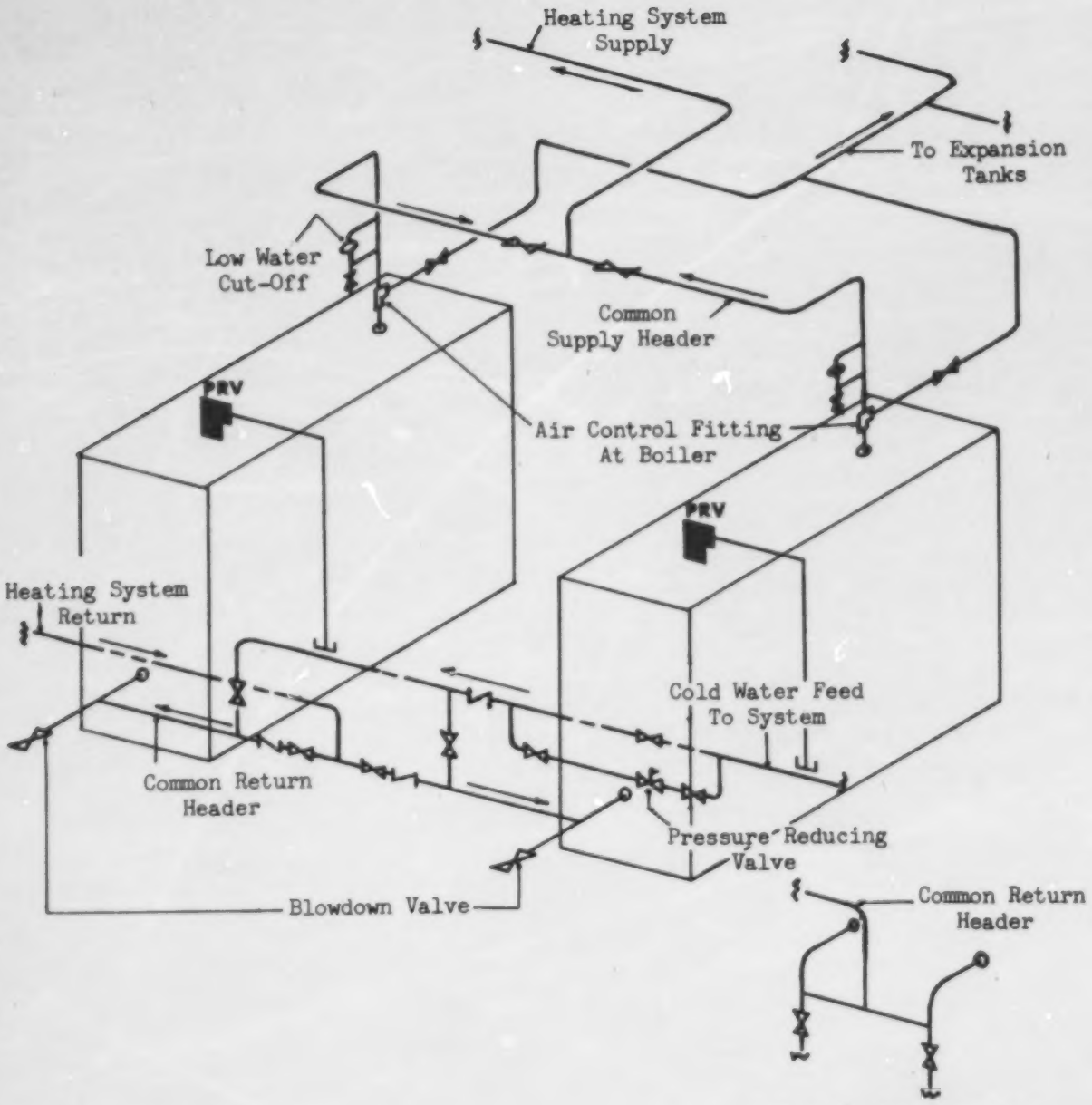
- 1507.00 The availability and costs of fuels and energy in the future appear to be unknown quantities. It seems possible that the time could come when energy will be rationed or assigned for the operation of both new and existing buildings. Owners and the design professions should begin to take a critical look at all buildings with energy consumption as a prime consideration.



STEAM BOILERS IN BATTERY

Piping Including Return Loop Connections

Hook-Up For Boiler With Two Return Tappings



Hook-Up For Boiler
With Two Return
Tappings

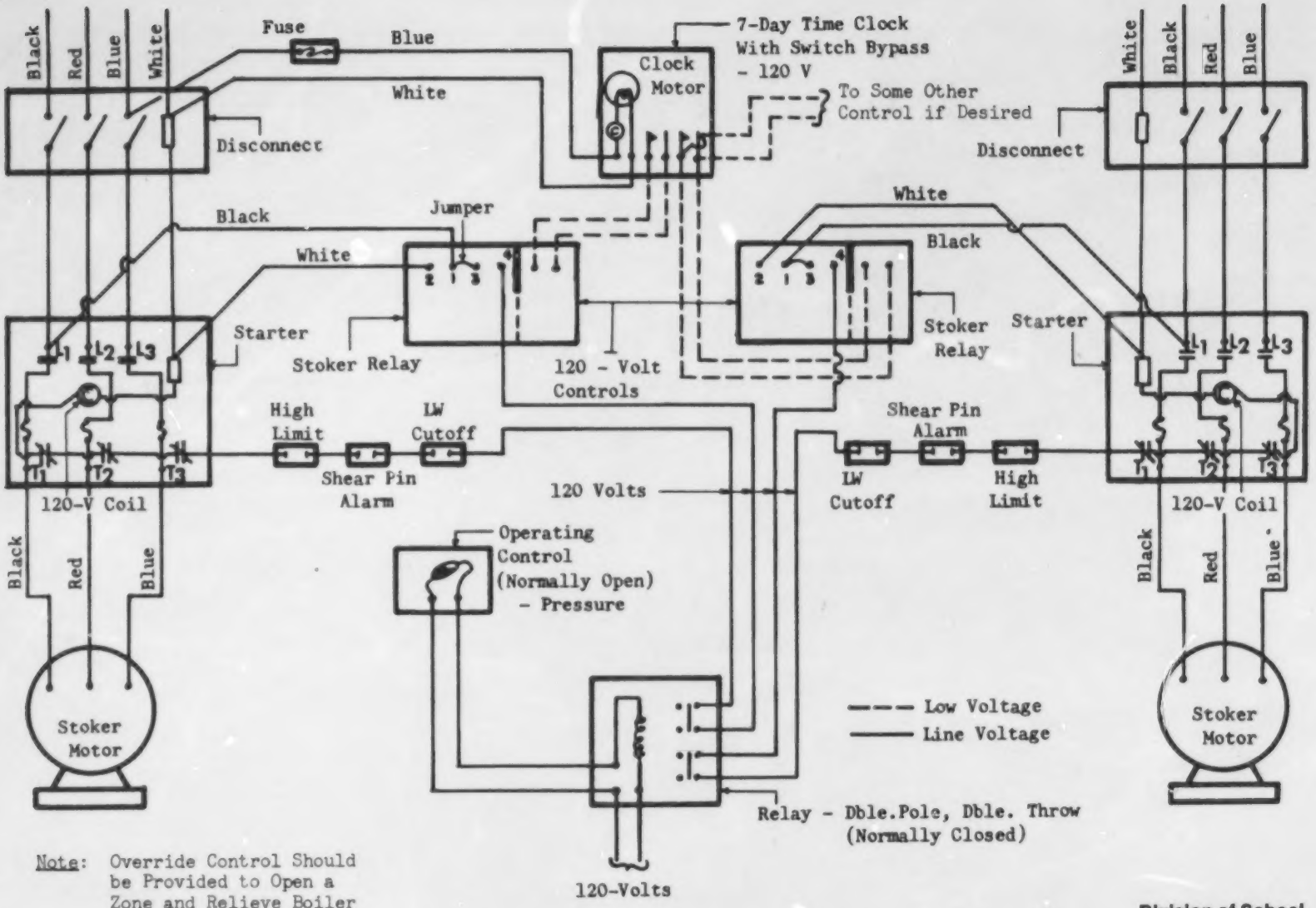
HOT WATER BOILERS IN BATTERY

Piping Arrangement

MECH 21

Division of School
Planning 1976

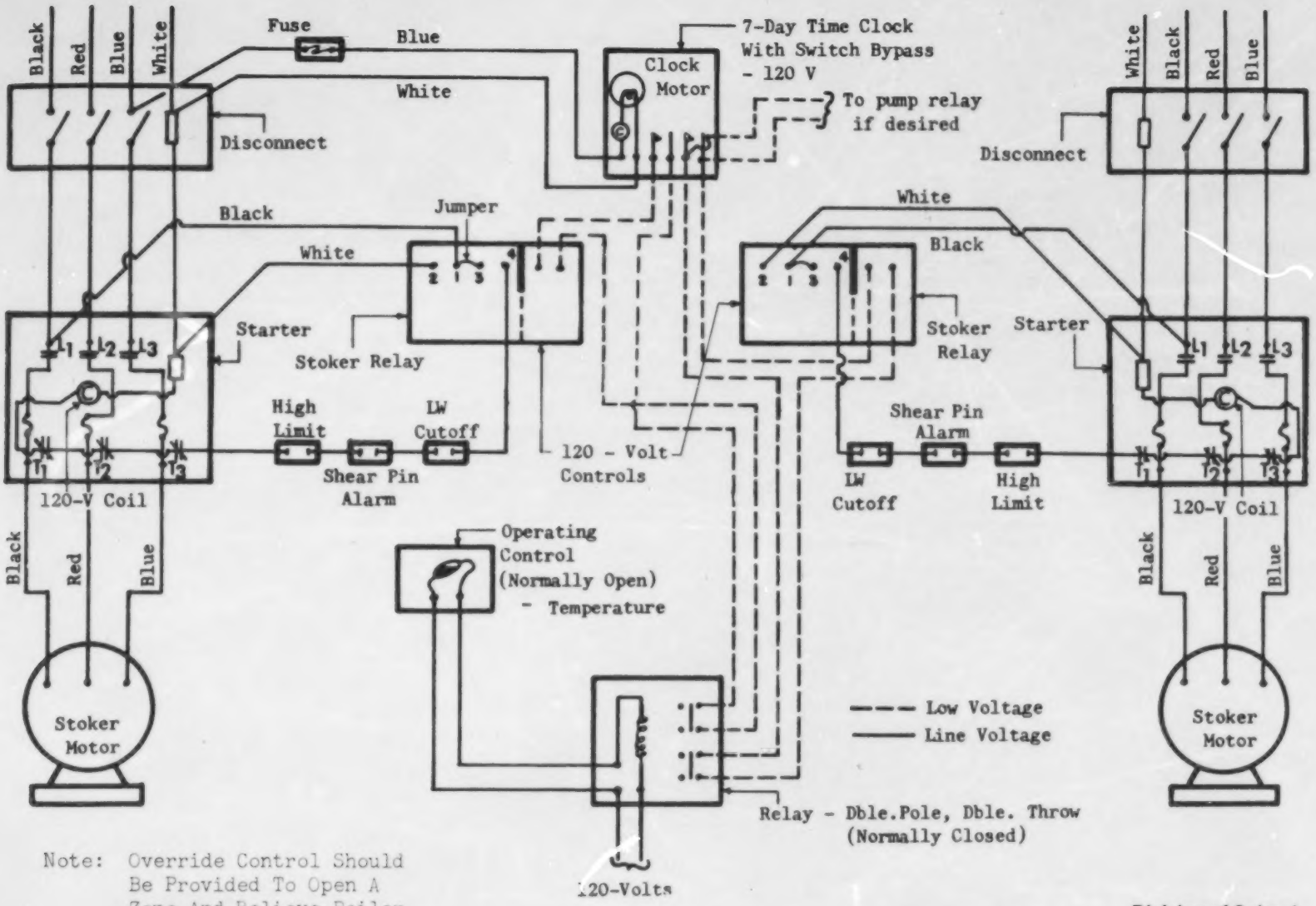
MECH 22



Note: Override Control Should be Provided to Open a Zone and Relieve Boiler Automatically When Necessary

TYPICAL STOKER CONTROL DIAGRAM - STEAM

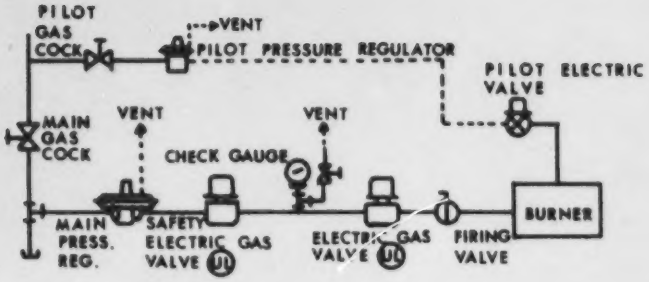
Division of School Planning 1976



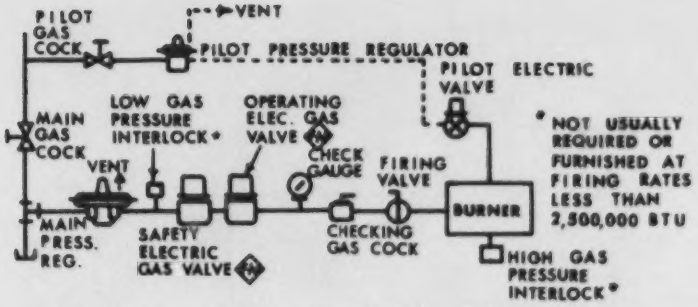
Note: Override Control Should Be Provided To Open A Zone And Relieve Boiler Automatically When Necessary

TYPICAL STOKER CONTROL DIAGRAM - HOT WATER

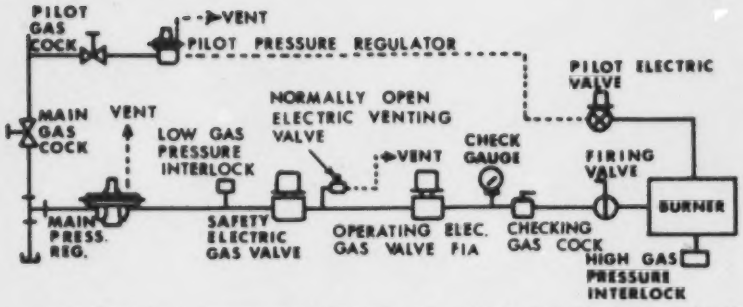
Division of School Planning 1976



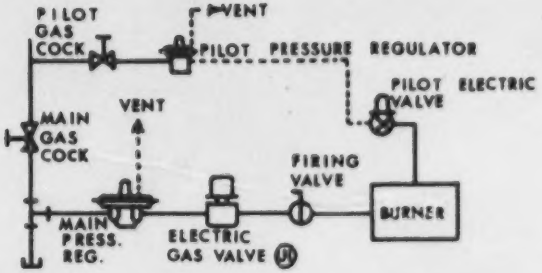
No. 1 U.L. - S.C.I. GAS PIPING GROUP (STANDARD)



No. 2 FACTORY MUTUAL GAS PIPING GROUP (FM)



No. 3 FACTORY INSURANCE ASSOCIATION GAS PIPING GROUP (FIA)



No. 4 U.L. PIPING GROUP (OPTIONAL)

SCHEMATIC ILLUSTRATION OF STANDARD PIPING OF GAS GROUPS (TRAINS)

NOTE: As a reference for the application of gas burner controls, the engineer is referred to the Underwriters' Laboratories Publication No. UL 795-1968.

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E-100.00 General

101.00 The electrical plans should include a riser diagram showing service conduit size, conduit type, service wire size and type (or bus duct), panels, switches, overcurrent device sizes, transformers (when used in the secondary system), feeder conduit sizes, feeder wire sizes and complete grounding and bonding details.

.01 Grounding and bonding details can best be shown by means of a separate diagram.

• 102.00 The electrical plans should include a numbered circuit diagram for each panel showing circuit use, circuit breaker size, circuit wire size, circuit conduit size, phase loads and total panel load.

103.00 The emergency system must be kept separate from all other wiring (NEC 700-17).

104.00 Where wire and equipment is oversized for future expansion or for equipment which may be added in the future, some notation of this on the plans is helpful to everyone concerned.

• 105.00 The entire system shall be color coded. Painting or taping should not be applied to wire of size number six or smaller.

.01 Two sets of colors should be used for color coding dual voltage systems (such as 277/480 and 120/208 volts). Color standardization for the phase conductors should be red, black and blue for 120/208-volt systems, and yellow, brown, and orange for 277/480-volt systems.

106.00 When long runs of wire are used, voltage drop should be considered (independent of spare capacity).

107.00 The electrical plans must bear the seal of the engineer who is responsible for the design and is by law obligated to inspect and issue a Certificate of Compliance upon completion of the project (NCGS 133-1.1).

108.00 All electrical plans and specifications should be coordinated; i.e., heating controls, general lighting and plumbing wiring.

.01 It is recommended that wiring and final connections for the control of mechanical equipment (heating and A/C controls) be a part of the mechanical contract.

109.00 Secondary voltage systems.

.01 The electrical plans should show the secondary voltage (preferably at the riser diagram).

.02 Acceptable secondary voltage systems:

.021 120/208-volts, 3-phase, 4-wire, wye.

.022 277/480 (or 265/460)-volts, 3-phase, 4-wire, wye.

.023 120/240-volts, 1-phase, 3-wire (refer to next item below).

.024 The single-phase system is acceptable only when the school is and will remain very small, for a small addition that is served separately or when it is impossible to get a three-phase system.

.025 Delta type systems (such as 120/240-volt 3-phase, 4-wire) are not desirable, and should be used as little as possible. One proper application might be the use of a 480-volt, delta service for distribution from which transformation to wye systems will be made throughout the site. Also, in a kitchen or a shop for example, which is served separately and has a high percentage use of 240-volt electricity, the 120/240-volt, 3-phase system could be applicable.

110.00 Reference is made to step-down transformers within the secondary system. Details for transformer wiring, grounding and bonding should be shown on the drawings. Attention is called to the diagrams showing typical grounding and bonding that follow in this section.

• .01 Conductors supplied from the secondary terminals of a dry type transformer, within the secondary electrical system, must be provided with overcurrent protection in accordance with the requirements of the NEC 240-3 and 240-21. Conductors from a single-phase transformer can be an exception.

• 111.00 Locations for step-down (dry type) transformers are important from the standpoints of safety and proper operation. Such transformers should never be located in wet areas or areas that are to be washed down by hosing. They should never be placed directly on the floor, but should be elevated to eliminate a possible water hazard; it is suggested that they be mounted on angle iron frames 18" high. Consideration should always be given to locating transformers in properly ventilated areas. The Division of School Planning feels that such transformers should not be directly accessible to students, but rather should be placed in equipment rooms, closets or similar spaces not frequented by students. Please refer to the NEC 450-21.

112.00 The specifications shall demand that all insulated conductors be marked on the outer covering, giving voltage, type and size so that they can be readily identified after installation.

113.00 There should be shown on the plans a complete electrical summary, either all or in part as is appropriate for a given school, as follows:

.01 The new load.

.02 The existing load; where this information is not available, the owner should make arrangements to provide it either by the design consultant or some other means.

.03 The capacity provided for known future expansion.

.04 The spare capacity provided if different from Item 113.03.

.05 The total capacity of the service.

114.00 In 20-ampere branch circuit wiring, some circuits are of such length that number ten wire must be used at the beginning of the run to avoid excessive voltage drop.

115.00 For general classrooms, one 20-ampere circuit should be used for the receptacles only in one classroom, and nothing else should be on this circuit. This is a minimum requirement. Special classrooms will require different considerations.

• 116.00 Reference is made to making buildings accessible to and usable by the physically handicapped (as required by the NCSBC). Please refer to Volume I, Section (IIX), Item 4.10 (Controls) and Appendix B (Public Telephones). This section must be complied with where required.

• 117.00 The electrical engineer is urged to work closely with the mechanical engineer to limit the load demand factor to the lowest possible and reasonable figure. This is extremely important with respect to monthly power bills to the owner, and apparently will become even more so. Clocks, other timing devices and perhaps other special control equipment should be carefully considered. Please refer to Item M-1208.00.

E-200.00 Service Drop

201.00 The location of the nearest power pole should be shown on the plans. This would be in addition to locating the padmounted transformer if one is used.

• 202.00 The service entrance should be detailed and dimensioned, showing the point of attachment to the structure along with the clearance of service wires over finish grade, drives and roofs (NEC 230-24 and 230-29).

.01 Flat roofs are considered as being of the type which can be readily walked upon regardless of the difficulty of gaining access to the roof level.

• 203.00 Connections at the service head must be made in accordance with requirements of the NEC, Article 230-54 (refer to Paragraphs (c), (f) and (g) in particular).

204.00 Attention is called to the sketch entitled "Wiring and Equipment Diagram" which follows in this section.

205.00 Underground services are highly recommended, both primary and secondary, and should be used in all cases where possible and justifiable (with respect to cost).

• .01 Routing for the underground service should be shown on a plot or site plan.

E-300.00 Service Equipment

301.00 All service equipment shall be bonded up to and including the first overcurrent device (NEC 250-71).

.01 Specifications should cover bonding, and bonding diagrams should be shown on the plans.

• .02 The bond wire used to carry the fault current of a parallel service, where two or more conduits are using the same jumper, shall be sized on the combined conductor capacity and not on the capacity of one set of conductors (NEC 250-79).

• 302.00 The emergency system shall be bonded up to and including its overcurrent device (NEC 250-71 and 250-75).

• 303.00 Switches, cabinets and cutout boxes of the surface type and metal raceways, boxes and fittings mounted on walls subject to dampness shall not be attached directly to the wall surface but shall have at least a ¼ inch air space between enclosures and the walls or other supporting surfaces (NEC 373-2).

• 304.00 Cabinets and cutout boxes in switchgear shall be increased in size to accommodate extra connections (NEC 373-7).

305.00 Grounding

• .01 Each individual building or structure shall have its ground and disconnecting means as required by the NEC (NEC 230-70, 230-84 and 250-24).

• .02 The ground connection shall be to the building water main (metallic pipe) and should be accessible. Point of attachment shall be shown on the plan.

.03 When the ground wire is protected by the use of conduit, the conduit and wire must be bonded together at both ends of the conduit (NEC 250-92).

.04 The size of the grounding conductor shall be shown on the plans.

• .05 It is possible that plastic or other nonconductive pipe for building water service might be installed. However, this is not recommended by the Division of School Planning. The electrical engineer is requested, when it is appropriate, to communicate with the plumbing design engineer to inform him that nonconductive pipe is useless as an electrical ground, and that metallic pipe is needed and recommended. In any event, proper grounding must be established in accordance with the requirements of the NEC, Articles 250-81 through 86.

306.00 Electrical service equipment should not be located in boiler rooms. This is definitely true if (1) coal fuel is used or (2) if boiler room is below grade. Where oil or gas fuel is used this equipment may be located in the boiler room, but it is not recommended. Also, and in all cases, electric service equipment located in a boiler room should be in a completely separate enclosure built just to house that equipment.

307.00 Service equipment should be specified as service equipment, and must have the U.L. label as such.

 308.00 For equipment interrupting capacity, reference is made to the NEC (NEC 110-9).

309.00 Attention is called to the sketch as indicated in E-204.00 above.

E-400.00 Distribution Equipment

401.00 Panel specifications must include special approved lugs where the conductors are run in multiple.

402.00 Bolt-in type breakers should be used in panels.

403.00 Breakers should be numbered and branch circuits should be installed as shown on the plans; shop drawings of panels should match the plans.

• 404.00 Do not allow more than one solid or stranded wire under one lug or screw type terminal unless it is approved for such use (NEC 110-14).

405.00 It is recommended that throated, insulated bushings be used on all EMT connectors.

406.00 Spare conduits should be included where spare breakers are provided in flush mounted panels.

407.00 Where the number of overcurrent devices are such that it becomes necessary to provide two panelboards mounted side by side, sufficient information shall be furnished the contractor to permit conduits to be run to the proper enclosure.

408.00 Proper panelboard protection is necessary (NEC 384).

409.00 The use of transformers to convert 208-volts to 240-volts for use in home economics ranges is not recommended.

E-500.00 Branch Circuits

501.00 Metal switch and receptacle cover plates are recommended.

502.00 Moistureproof switches and fixtures must be used in wash areas, shower rooms, freezer and refrigeration rooms and other such places that are likely to be subjected to water or moisture (NEC 410-4 and 370-5).

503.00 Do not use flush floor-type receptacles in kitchens or like places subject to washing down and mopping.

504.00 At least one duplex outlet is needed in the boiler room.

505.00 Junction and pull boxes, as a minimum, shall be sized according to Code (NEC 370-18).

506.00 A multi-wire branch circuit, as defined by the NEC, Section 210-4, shall be connected in such a manner that the neutral will not carry more than the maximum load of any one of the "hot conductors" in the circuit.

• 507.00 All locknuts must be tightened during installation (NEC 300.10 — See the definition of branch circuit).

508.00 Do not load branch circuits to more than eighty percent of their rated capacity (NEC 210-23).

• 509.00 Fluorescent fixtures mounted on combustible, low density, cellulose fiber board shall be installed as required by the Code (NEC 410, Par. N).

510.00 The NEC requires that a minimum of three (3) watts per square foot of floor area in branch circuit capacity, for lighting, be provided in school classrooms (NEC 220-2).

511.00 Deleted.

E-600.00 Motors and Equipment

• 601.00 Where raceway flexibility is desired at the point of connection to the motor or piece of equipment, flexible conduit must be installed in accordance with Code requirements (NEC 350).

• 602.00 Thermal overload protection shall be provided for every motor as required by Code (NEC 430, Par. C).

.01 Running overcurrent protection for three-phase motors must be provided in each phase, all as required in NEC, Article 430-37.

603.00 Each motor shall be within sight of its disconnecting means. More than fifty feet is considered out of sight. (See the NEC, 430-4, 430-86 and 430-106).

• 604.00 Caution should be used in selecting 480 or 460-volt equipment for kitchens (refer to Item 903.01).

605.00 All electrical devices, appliances and equipment used in public schools must have Underwriters' Laboratories approval as required by NCGS 66-25. Such approval shall be called for in the specifications.

E-700.00 Emergency Lighting, Systems and Power

701.00 Emergency and exit lighting must conform to requirements of the NCSBC. Attention is directed to Section 1124—Illumination of Exits, and Section 1125—Exit Signs.

702.00 Numerous plans are submitted to the Division of School Planning incorporating emergency and exit lighting systems that do not conform to Code requirements because of errors or omissions. Engineers and architects are encouraged to become familiar with Code requirements.

• 703.00 Exit lights should be of very low wattages. It is desirable that exit fixtures be of the long life type (providing approximately 60,000 hours of lamp life).

704.00 Three-way and four-way switches cannot be used in the emergency system (NEC 700-18).

705.00 Manually operated switches for the exit and/or emergency system should be accessible only to authorized personnel (NEC 700-19).

706.00 The emergency system shall not be controlled from the stage of an assembly area (NEC 700-19).

707.00 With reference to Item 701.00 above, emergency lighting must be provided in accordance with Code requirements. In particular, cafeterias, gymnasiums, auditoriums and other assembly areas that will accommodate more than 100 persons must have emergency illumination.

• *.01* Some school buildngs will have some interior spaces, with no available daylight, that will be occupied by students. Examples of such spaces might be classrooms (where the condition is unavoidable) or locker and dressing rooms. These spaces should have emergency illumination provided to prevent total blackout in case of power failure.

• *.02* Reference is made to high intensity discharge (HID) lighting. In an area where such lighting is used, a minimum and supplementary system of either incandescent or fluorescent lighting should be provided to furnish enough light to prevent panic in case of an outage (and consequent delay in light output) in the HID lamps.

708.00 Fire alarm systems are required for public school buildings. Attention is called to the NCSBC, Section 1126.

709.00 Automatic smoke detectors are necessary and/or applicable in public school buildings. Designers are referred to and should become familiar with the NCSBC Section 1127 and Section 1117 (specifically 1117.1).

710.00 Special provisions in the NCSBC can require the application of particular types of emergency power sources. The designing engineer is referred to Table 1125 in Chapter XI of this Code.

• 711.00 Experience has shown that battery powered emergency illumination systems (when an independent power source is required) are much to be preferred over generators. Ease of maintenance is one important reason for this. Battery powered systems are therefore recommended and encouraged.

E-800.00 General Illumination

801.00 Close cooperation by the architect, engineer and school administrator(s) must be achieved to obtain the good lighting system design necessary for a proper visual environment. There are always at least four factors, directly related to the visual environment, that must be considered when designing the lighting system. These are:

(a) Levels of illumination
(b) Reflectances (and ranges of reflectances)
(c) Brightness (and brightness ratios)
(d) Contrasts

.01 A table of recommended levels of illumination for schools can be found following herein.

802.00 The overall procedure for designing the lighting system might follow such a course as this:

1. Establish desired environment
   a. Brightness and brightness ratios
   b. Colors and textures
   c. Method of daylighting and daylight controls
2. Establish reference task and required illumination levels
   a. General or academic classrooms
   b. Special purpose areas — labs, libraries, shops, etc.
3. Establish general illumination system
   a. Distribution characteristics of light sources
   b. Coordinate with effect of task visibility
   c. Coordinate with total environment
      (1) Characteristics of heat and noise production
      (2) Color acceptability
      (3) Special and esthetic characteristics
4. Establish supplementary illumination
   a. Chalkboards, special tasks and special areas
5. Establish audiovisual requirements
6. Analyze economics
   a. Capital expense
   b. Maintenance expense
   c. Electrical energy cost

.01 A great number of lighting systems designed for schools incorporate the use of 4-tube, 2-ballast luminaires. In such cases it is easy to provide for switching of the lights so that either all or one-half the tubes are energized. The Division of School Planning feels that this is a worthwhile design consideration in that energy can be saved when appropriate or necessary. This method of light switching is recommended in all systems where it is possible.

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803.00 Outdoor lighting should be done with respect to the owner's desires, adequate lighting of areas used in traveling to and from the building, and for the purpose of discouraging vandalism.

804.00 Athletic field lighting and wiring require some careful thought. In addition to the consideration of lighting intensities, fixture selection and arrangement and fixture quality, the engineer should concern himself with the safety of the installations, and the requirements of both the NEC and the National Electrical Safety Code. Underground distribution is highly recommended and encouraged.

805.00 As an overall reference for this section, please refer to Illuminating Engineering Society Lighting Handbook.

E-900.00 All-Electric Schools and Electric Heating

901.00 The decision for the type heating for a school, when considering all-electric energy, should be made by the owner. Accurate and unbiased cost studies should be prepared by the engineer and architect when directed. The Division of School Planning would welcome the opportunity to share in analyzing such studies.

• 902.00 For all-electric schools, those using electricity for space heating, it is recommended that 277/480 (or 265/460)-volt systems be used for the secondary voltage. It is felt that this voltage is justified economically in all cases unless the school is very small, and will definitely remain so. Due regard must still be given to safety, and the qualifications of school maintenance personnel. Further, this voltage should be used for any school project where size justifies its economics.

903.00 Where 277/480 or (265/460)-volt systems are used for secondary voltage, it is recommended that these voltages be used, within reason, to the fullest extent possible. That is, they are recommended for (1) lighting, (2) water heating, (3) space heating (where electric space heating has been chosen) and (4) larger motor loads where practicable. Proper and adequate equipment grounding, for safety purposes, must be clearly defined.

• *.01* Attention is directed to the consideration of using 277/480 (or 265/460)-volts electricity for kitchen equipment. Apparently this has now become a matter of economic importance. Heretofore the Division of School Planning had recommended against it. The following comments are in order at this time. (1) Larger items of equipment, such as steamers, ovens and surface burner units can be served with this higher voltage; also, the booster water heater for the dishwasher. (2) Smaller items of equipment and portable equipment should not be at 277/480. (3) The dishwasher itself, in its entirety, should never be of the higher voltage. This is a "wet" machine in a wet area, and the hazard should be minimized. For all kitchen electrical equipment positive equipment grounding should be established. A grounding system for this should be designed by the engineer and shown on the plans.

904.00 All instructional shop equipment must still be served by the lower voltages such as 120/280-volts.

905.00 All electrical space heating equipment must bear the Underwriters' Laboratories approval (NCGS, Chapter 66, Article IV).

• **E-1000.00 Sound Systems and Clock and Bell Systems**

• 1001.00 Sound systems may be simple or somewhat complex as the owner desires. Systems can be designed for one or two way communication, and for schoolwide sound distribution from one central point. In the initial design, it is recommended that the degree of sophistication be limited to a system that the owner will actually make use of.

• 1002.00 Clock and bell systems provide for the orderly control of periods within the school day, and are recommended. Systems and equipment should be kept reasonably simple in the best interest of both operation and maintenance. Complex systems that are continually out of order are obviously undesirable.

E-1100.00 Television Reception and Distribution Systems; Master Antenna Television (MATV), Closed Circuit Television (CCTV), Community Antenna Television (CATV) or Multiple Source Television (MSTV)

1101.00 General

.01 The decision for inclusion of television, the number of channels, which channels, system size, whether or not the system will be MATV, CCTV or MSTV is a decision that should be made by the owner.

.02 Prior to the preparation of specifications and drawings an on-site television field strength survey should be made for each channel desired. Measurement data obtained from field strength survey should be noted on television system riser diagram.

.03 A duplicate set of system drawings and equipment manuals should be received by the owner prior to final system acceptance.

.04 System acceptance inspection will be rendered by the Division of School Planning, or its appointed representative after the system has been in operation for approximately thirty (30) days.

1102.00 System Requirements

.01 The television distribution system as a whole shall be or shall provide:

.011 +3 dbmv minimum output at all taps for each channel.

.012 +12 dbmv maximum output at all taps for each channel.

.013 20 db minimum isolation between taps.

.014 Lines terminated in characteristic impedance.

.015 Type F or quick disconnect type G connectors at all taps.

.016 Free of interference, ghosts and smear on all channels at all taps.

.017 An overall signal-to-noise ratio of 40 db for a 6 Mhz bandwidth.

.018 Flatness of response: 3 db maximum peak to valley across any one 6 Mhz channel and 5 db maximum peak to valley across the system bandwidth.

.019 *VHF only;* desired UHF signals are electronically converted to a preselected VHF channel prior to distribution.

1103.00 Component Requirements

.01 All antenna down lead and distribution cables shall be 75 ohm foam dielectric, type RG-6. Cable shield shall be of aluminized mylor surrounded by a minimum 50% aluminum wire braid.

.02 System amplification shall be accomplished by AGC controlled single channel strip amplifiers.

.03 All electronic equipment shall utilize solid state construction.

.04 The *VHF* antenna(s) shall be of the single channel, ruggedized MATV type designed to produce optimum signals in strength and quality as required for each TV channel specified.

.05 The UHF antenna(s) shall be of the rugged MATV type designed to produce optimum signals in strength and quality as required for each TV channel specified.

.06 Antenna(s) shall be side mounted on an *approved* tower meeting EIA RS-222-B specifications,

OR

- .07 Antenna(s) shall be side mounted on an *approved* tapered steel support structure meeting EIA RS-222-B specifications,

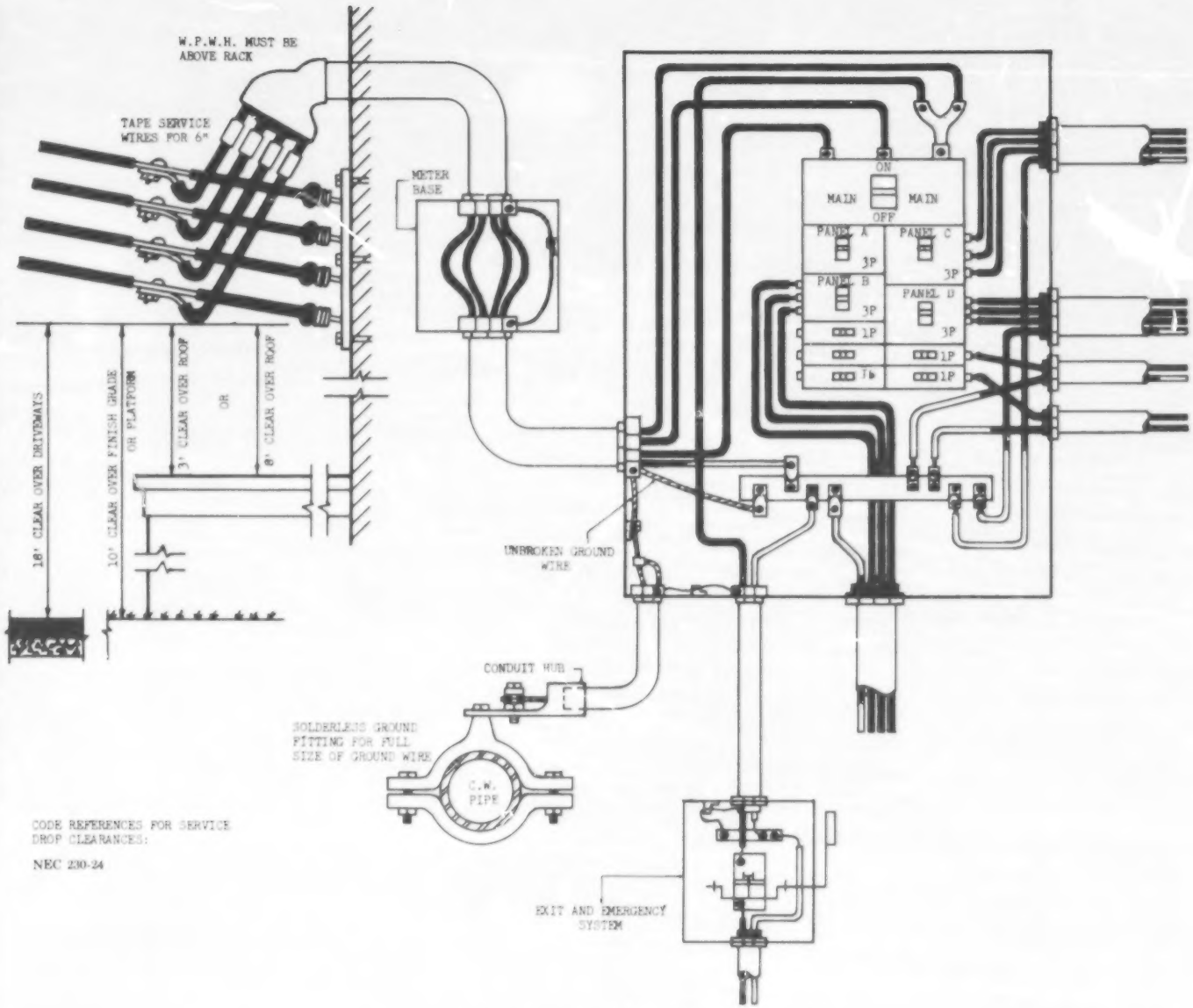
OR

- .08 Antenna(s) shall be side mounted on an *approved* tapered aluminum support structure. Such a structure shall meet the intent of EIA RS-222-B specifications,

OR

- .09 Antenna(s) shall be vertically stacked on an *approved* single or telescopic mast support structure meeting EIA RS-222-B specifications.
- .10 Antenna(s), antenna mounts and antenna support structure(s) shall be selected to provide wind loading within range as specified by EIA RS-222-B and structure manufacturer for the area in which structure is to be erected.
- .11 Antenna(s) shall be mounted in such a manner so as to provide a minimum above ground elevation of thirty (30) feet. Roof mounted antenna(s) shall provide, in *addition to* the thirty (30) foot above ground elevation, a minimum above the roof clearance of eight (8) feet for low band antenna(s), four (4) feet for high band antenna(s), and three (3) feet for UHF antenna(s).
- .12 Antennas of different frequency shall be mounted with vertical spacing of at least 0.65 times the wavelength of the lower visual carrier frequency.
- .13 UHF to VHF conversion of a system signal shall be accomplished by a crystal controlled converter.
- .14 System splitters shall have a bandwidth of from 5 to 300 Mhz.
- .15 System wall taps shall be of the directional coupler type with a bandwidth of from 5 to 300 Mhz.
- .16 Head-end distribution equipment and other associated components shall be enclosed within a wall mounted housing. Equipment housing shall be suitable for EIA 19" rack size head-end mounted distribution equipment. Housing must be ventilated and lockable.
- 1104.00 Electrical Requirements
- .01 There should be adequate power wiring provided in each equipment housing. One hundred percent of the power outlets required to do the specified job plus a reserve of 25% should be included for possible future expansion.
- .02 Head-end equipment housing should be on a separate power circuit.
- 1105.00 Head-end Location
- .01 The head-end equipment should be located within the Media-Center complex, preferably in a storage area.
- 1106.00 Television Conduit System
- .01 Wherever possible, television conduit systems shall consist of a single piece of 3/4" EMT extending upwards from each standard 2" x 4" wall box. Each piece of EMT shall be extended above the ceiling, stubbed off and bushed.
- .02 Wherever possible, a single 1-1/2" conduit should be provided between head-end equipment housing and antenna location or other single source location.
- .03 Two (2) 1-1/2" conduits should be provided between head-end equipment housing and above ceiling space.
- .04 Individual 1-1/4" conduit runs should be provided between head-end equipment housing and remote located television distribution junction boxes.
- 1107.00 Wall Tap-off Location

- .01 For standard television receiver mount, tap-off should be located no higher than 48" AFF.
- .02 For ceiling or wall mounted television receiver, tap-off should be located in as close proximity to the receiver as possible.
- 1108.00 Applicable References
- .01 Electronic Industries Association's Standards and Specifications (EIA)
  Federal Communication Commission's Rules and Regulations (FCC)
  National Electrical Code (NEC)
  National Television System Committee Standards (NTVS)
  Underwriters' Laboratories Listing (UL)



CODE REFERENCES FOR SERVICE DROP CLEARANCES:

NEC 230-24

WIRING AND EQUIPMENT DIAGRAM

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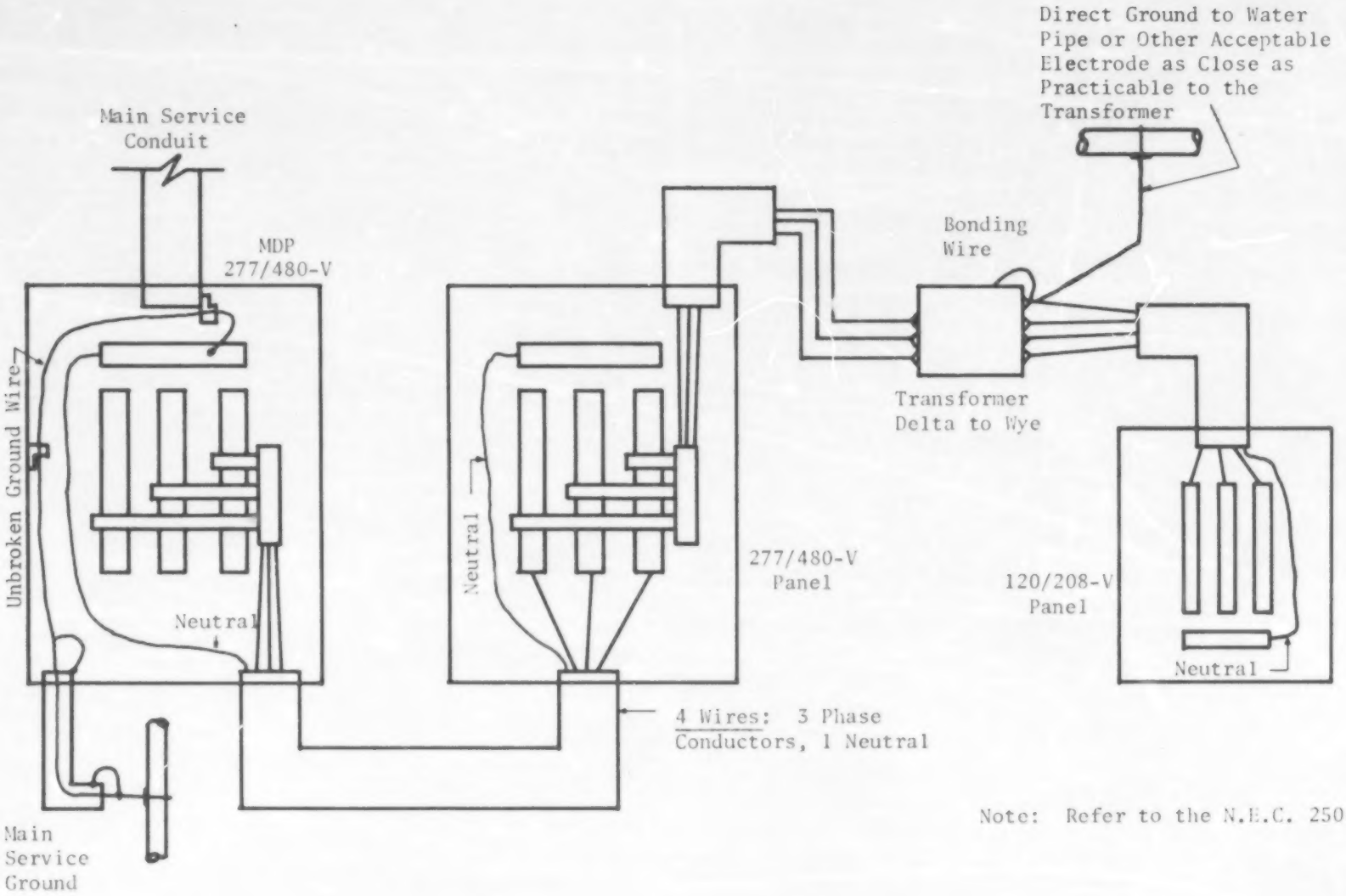

Note: Refer to the N.E.C. 250-26

277/480-VOLT AND 120/208-VOLT SYSTEMS SHOWING GROUNDING METHOD - THIS DIAGRAM IS FOR ONE BUILDING ONLY ON THE SITE

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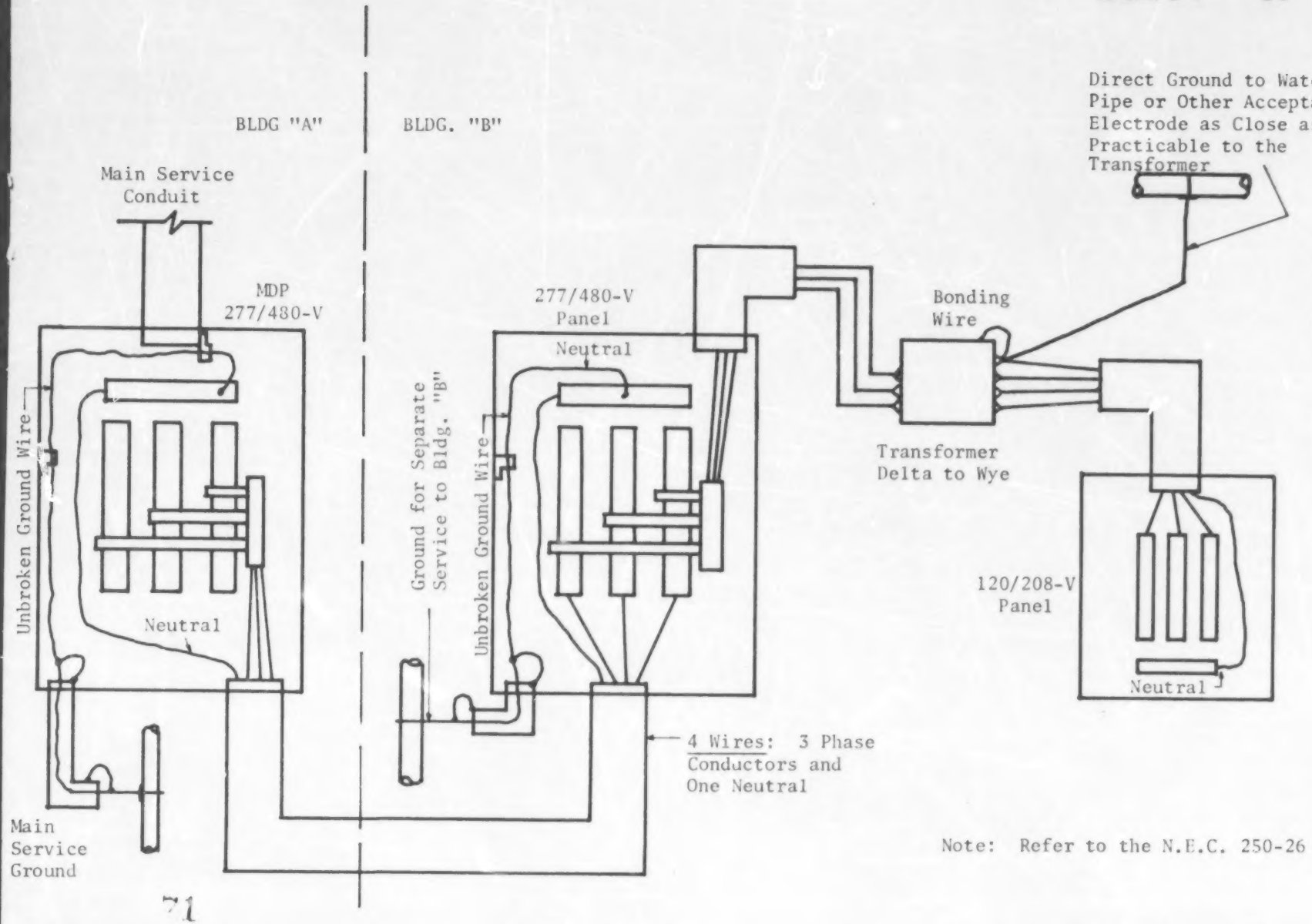

Note: Refer to the N.E.C. 250-26

277/480-VOLT AND 120/208-VOLT SYSTEMS SHOWING GROUNDING METHOD - THIS DIAGRAM IS FOR MORE THAN ONE BUILDING ON THE SITE

TYPICAL ELECTRICAL SUMMARY

(Refer to Item E-113.00)

ELECTRICAL LOAD SUMMARY

(A) SERVICE

120/208-Volts, 3-Phase, 4-Wire Wye with Full Neutral; 1600-Amp. Switchboard and 1200-Amp. Service Entrance with Empty Conduit to Increase Service Entrance to 1600-Amps.

(B) CONNECTED LOAD	KW		AMPS	
(1) EXIST. BLDG.				
Ltg.	99.0		275	
Rec. & Spares	60.0		166	
Kitchen	142.00		395	
Water Htr.	37.0		101	
Sub-Totals		338.0		937
(2) NEW BLDG.				
Ltg.	45.0		125	
Rec. & Spares	38.0		103	
		83.0		228
Sub-Totals		421.0		1165
(3) FUT. AIR COND. & OTHER LOADS		188.0		520
Totals		609.0		1685

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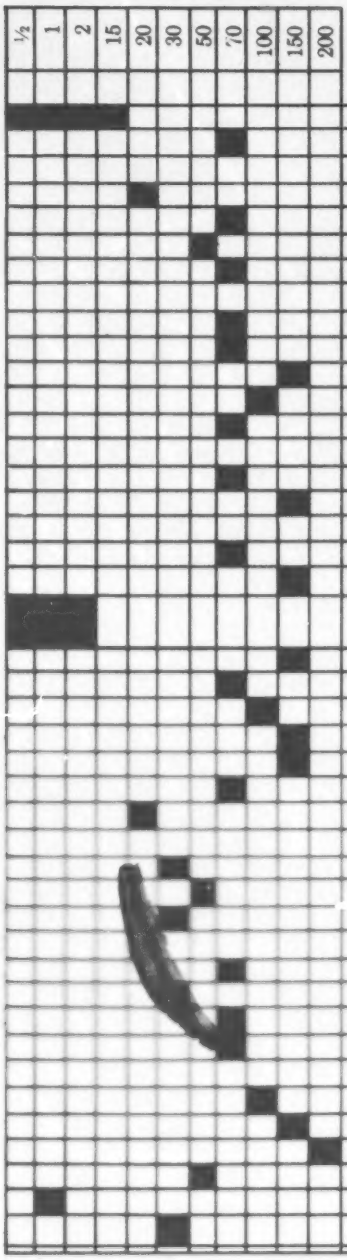
Recommended Minimum Footcandles



ILLUMINATION LEVELS FOR VARIOUS TASKS & LOCATIONS IN SCHOOLS

AUDITORIUMS (seating area only)
- Assembly only (Dimming equipment desirable)
- Study Halls

CAFETERIAS
- Eating only
- When used for study halls
- Food Displays
- Kitchens

CLASSROOMS
- Regular classroom work
- Art rooms
- Chalkboards (Supplementary illumination)
- Drafting rooms
- Home Economics rooms
- Laboratories
  - General
  - Close work
- Lecture and demonstration rooms
  - General
  - Special exhibits and demonstration
  - When projection equipment is used (dimming equipment desirable)
- Lipreading classrooms
- Music rooms
- Manual arts rooms
- Sewing rooms
- Sightsaving classrooms
- Typing rooms

CORRIDORS & STAIRS

GYMNASIUMS
- General exercising
- Exhibition games
- Locker and shower rooms

LIBRARIES
- Reading rooms and carrels
- Stacks
- Book repair and binding
- Check-in, checkout, catalogs, card files

OFFICES
- Regular office work
- Acct., auditing, tabulating, bookkeeping, etc.
- Cartography, designing, detailed drafting
- Conference rooms

PARKING LOTS

TOILETS & WASHROOMS

The level of illumination should be provided on the task regardless of location in the room, or position. The initial value of illumination must be greater than the minimum value to compensate for lamp depreciation and dirt collection on all surfaces. These are recommended standards of the I. E. S.

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